CE6361 Groundwater Hydrology , HW#5, Fall 199_ Due: ______________

1) A test well was drilled to a total depth of 117 feet with the following geologists log:

| | |
|---|---|
| 0 - 73 feet | Coarse sand |
| 73 - 82 feet | Clayey sand |
| 82 - 117 feet | Coarse sand |
| 117 feet | Crystalline bedrock |

The depth to water was 55 feet. The test well was screened from 82 to 117 feet. It was pumped at a rate of 560 gallons per minute. Drawdown was measured in an observation well that was also screened from 82 to 117 feet and was located 82 feet away from the pumping well. The following data were collected:

| Elapsed Time (minutes) | Drawdown (feet) |
|---|---|
| 0 | 0.00 |
| 1 | 0.90 |
| 2 | 2.15 |
| 3 | 3.05 |
| 4 | 3.64 |
| 5 | 4.07 |
| 6 | 4.52 |
| 7 | 4.74 |
| 8 | 5.02 |
| 9 | 5.21 |
| 10 | 5.53 |
| 15 | 5.72 |
| 20 | 5.97 |
| 30 | 6.12 |
| 40 | 6.20 |
| 50 | 6.25 |
| 60 | 6.27 |
| 90 | 6.29 |
| 120 | 6.29 |

(a) Draw a schematic of the aquifer system described by the geologic log. Indicate the relative positions of the pumping and observation well.

(b) Compute the value of storativity and transmissivity for the aquifer system. If your data suggest a leaky system, estimate the vertical hydraulic conductivity of the confining layer.

2) A slug test was made in a piezometer that had a casing radius of 2.54 centimeters and a screen radius of 2.54 centimeters. A slug of 4000 cubic centimeters was injected; this slug raised the water level by 197.3 cm. The well completely penetrated a confined stratum that was 2.3 meters thick. The data from the test are listed below. Estimate the transmissivity and storativity for the stratum.

| Time (seconds) | Head(feet) |
|---|---|
| 0 | 197.3 |
| 1 | 185.4 |
| 2 | 178.6 |
| 3 | 173.6 |
| 5 | 167.7 |
| 7 | 158.8 |
| 10 | 147.0 |
| 13 | 140.0 |
| 17 | 129.2 |
| 22 | 118.4 |
| 32 | 99.6 |
| 53 | 74.0 |
| 84 | 51.3 |
| 119 | 35.3 |
| 170 | 23.3 |
| 245 | 15.2 |
| 400 | 8.7 |
| 800 | 4.3 |

3) The following data were obtained from a pumping test where a well was pumped at a rate of 200 gallons per minute. Drawdown was measured in an observation well 250 feet away from the pumped well. The geologist log of the pumping well is:

| | | |
|---|---|---|
| 0 - 23 feet | | Glacial till, brown, clayey |
| 23 - 77 feet | | Dolomite, fractured |
| 77 - 182 feet | | Shale, black, dense |
| 182 - 217 feet | | Sandstone, well-cemented, coarse |
| 217 - 221 feet | | Shale, gray, limy |

A steel casing was cemented to a depth of 182 feet and the well was screened from 182 feet to its total depth of 221 feet.

| Elapsed Time (minutes) | Drawdown (feet) |
|---|---|
| 0 | 0.00 |
| 1 | 0.66 |
| 1.5 | 0.87 |
| 2 | 0.99 |
| 2.5 | 1.11 |
| 3 | 1.21 |
| 4 | 1.36 |
| 5 | 1.49 |
| 6 | 1.59 |
| 8 | 1.75 |
| 10 | 1.86 |
| 12 | 1.97 |
| 14 | 2.08 |
| 18 | 2.20 |
| 24 | 2.36 |
| 30 | 2.49 |
| 40 | 2.65 |
| 50 | 2.78 |
| 60 | 2.88 |
| 80 | 3.04 |
| 100 | 3.16 |
| 120 | 3.28 |
| 150 | 3.42 |
| 180 | 3.51 |
| 210 | 3.61 |
| 240 | 3.67 |

(a) Draw a schematic of the aquifer system described by the geologic log. Indicate the relative positions of the pumping and observation well.

(b) Compute the value of storativity and transmissivity for the aquifer system. If your data suggest a leaky system, estimate the vertical hydraulic conductivity of the confining layer.

4) The effect of hydrologic boundaries is usually evidenced by departures of time drawdown data from theoretical curves. These departures can be analyzed to locate the type of boundaries and their contribution to total flow. Prepare time drawdown curves for the three cases below:

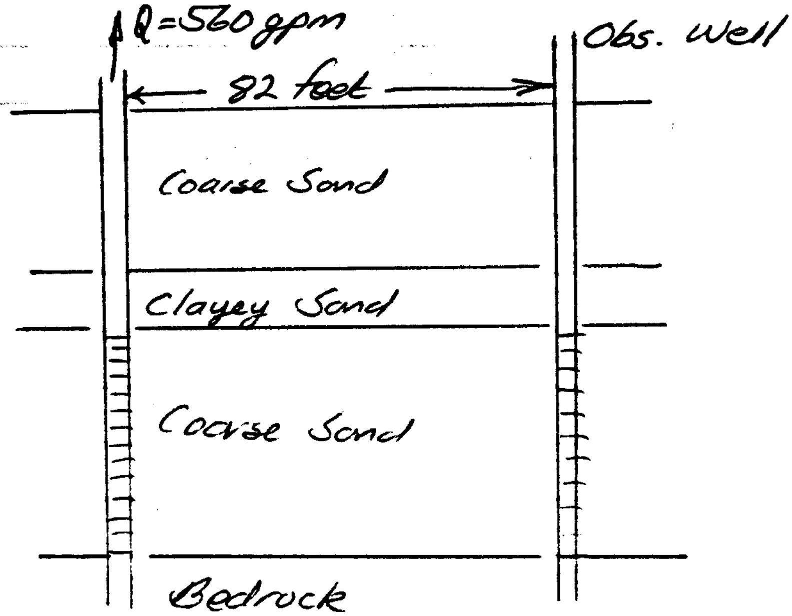
(a) An observation well located 100 feet from a pumped well in a homogeneous, isotropic, confined aquifer. The pumped well is operated at a rate of 200 gpm, T = 2000 gpd/ft, and S=0.001.

(b) Same as above, except the observation well is located between the pumping well and a recharge (constant head) boundary that is located 500 feet from the pumping well.

(c) Same as above, except the boundary is a no-flow boundary.

(d) Comment on the time drawdown patterns for recharge and no-flow boundaries.

#1 a)




b) Evidence of leakage see attached worksheets

Match Point $r/B = 1.0$

$W(u, \frac{r}{B}) = 1.4$ $\frac{t}{r^2} = 10^{-2} (\frac{min}{ft^2})$

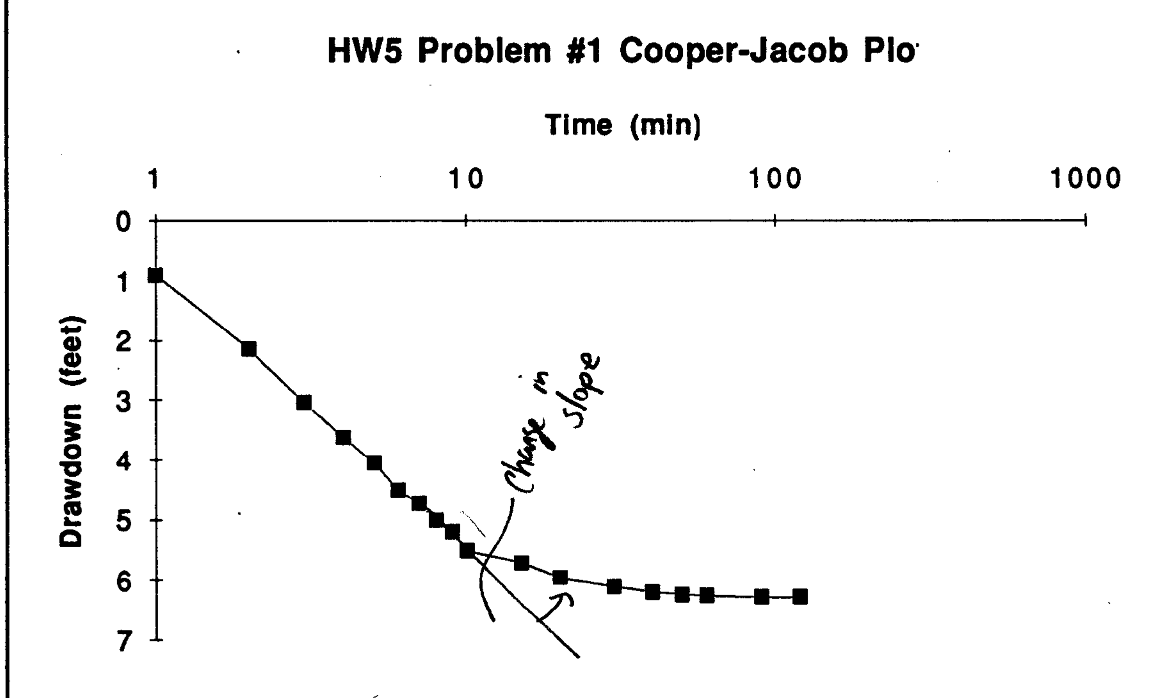
$\frac{1}{u} = 50$ $s = 10 ft$

$$T = \frac{560 gpm}{4\pi(10 ft)} 1.4 = 6.238 \frac{gpm}{ft} \cdot \frac{ft^3}{7.48 gal} = \frac{0.834 ft^2}{min}$$

$$S = (\frac{1}{50}) 4 (0.834 \frac{ft^2}{min}) 10^{-2} (\frac{min}{ft^2}) = 6.67 \cdot 10^{-4}$$

$$K' = \frac{(0.834 \frac{ft^2}{min})(9 ft)(1.0)^2}{(82 ft)^2} = 1.116 \cdot 10^{-3} ft/min$$

| | | | | | |
|---|---|---|---|---|---|
| HW5 Problem#1 Data | | r= 82 ft | | | |
| | Time(min) | S (feet) | t/r^2 | | |
| | 0 | 0 | 0 | | |
| | 1 | 0.9 | 0.000148721 | | |
| | 2 | 2.15 | 0.000297442 | | |
| | 3 | 3.05 | 0.000446163 | | |
| | 4 | 3.64 | 0.000594884 | | |
| | 5 | 4.07 | 0.000743605 | | |
| | 6 | 4.52 | 0.000892326 | | |
| | 7 | 4.74 | 0.001041047 | | |
| | 8 | 5.02 | 0.001189768 | | |
| | 9 | 5.21 | 0.001338489 | | |
| | 10 | 5.53 | 0.00148721 | | |
| | 15 | 5.72 | 0.002230815 | | |
| | 20 | 5.97 | 0.00297442 | | |
| | 30 | 6.12 | 0.00446163 | | |
| | 40 | 6.2 | 0.00594884 | | |
| | 50 | 6.25 | 0.00743605 | | |
| | 60 | 6.27 | 0.00892326 | | |
| | 90 | 6.29 | 0.01338489 | | |
| | 120 | 6.29 | 0.01784652 | | |




*Change in slope suggests recharge boundary or leakage - use hantush method for ana

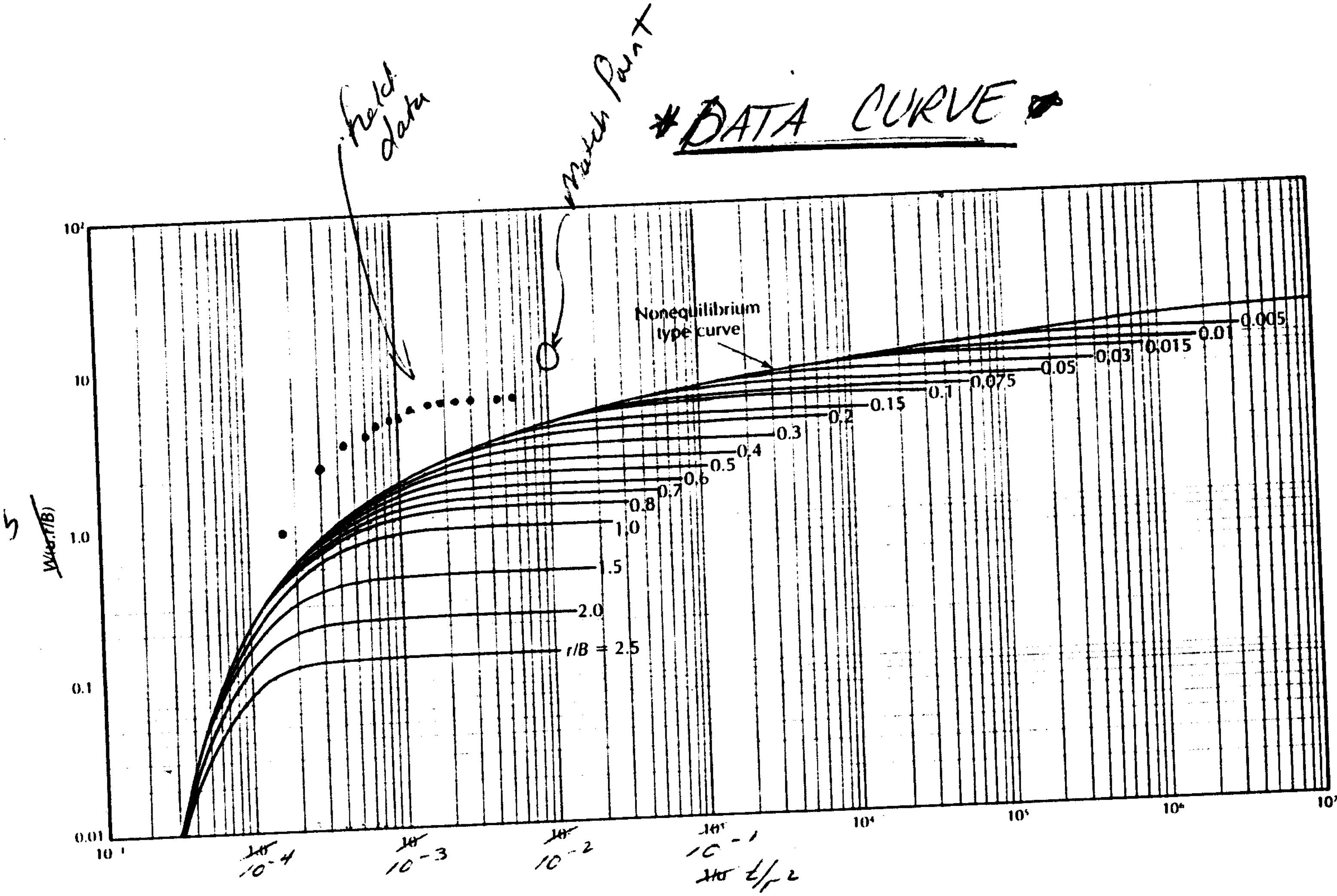



FIGURE 6.13 Type curves of leaky artesian aquifer in which no water is released from storage in the confining layer. Source: W. C. Walton, Illinois State Water Survey Bulletin 49, 1962.

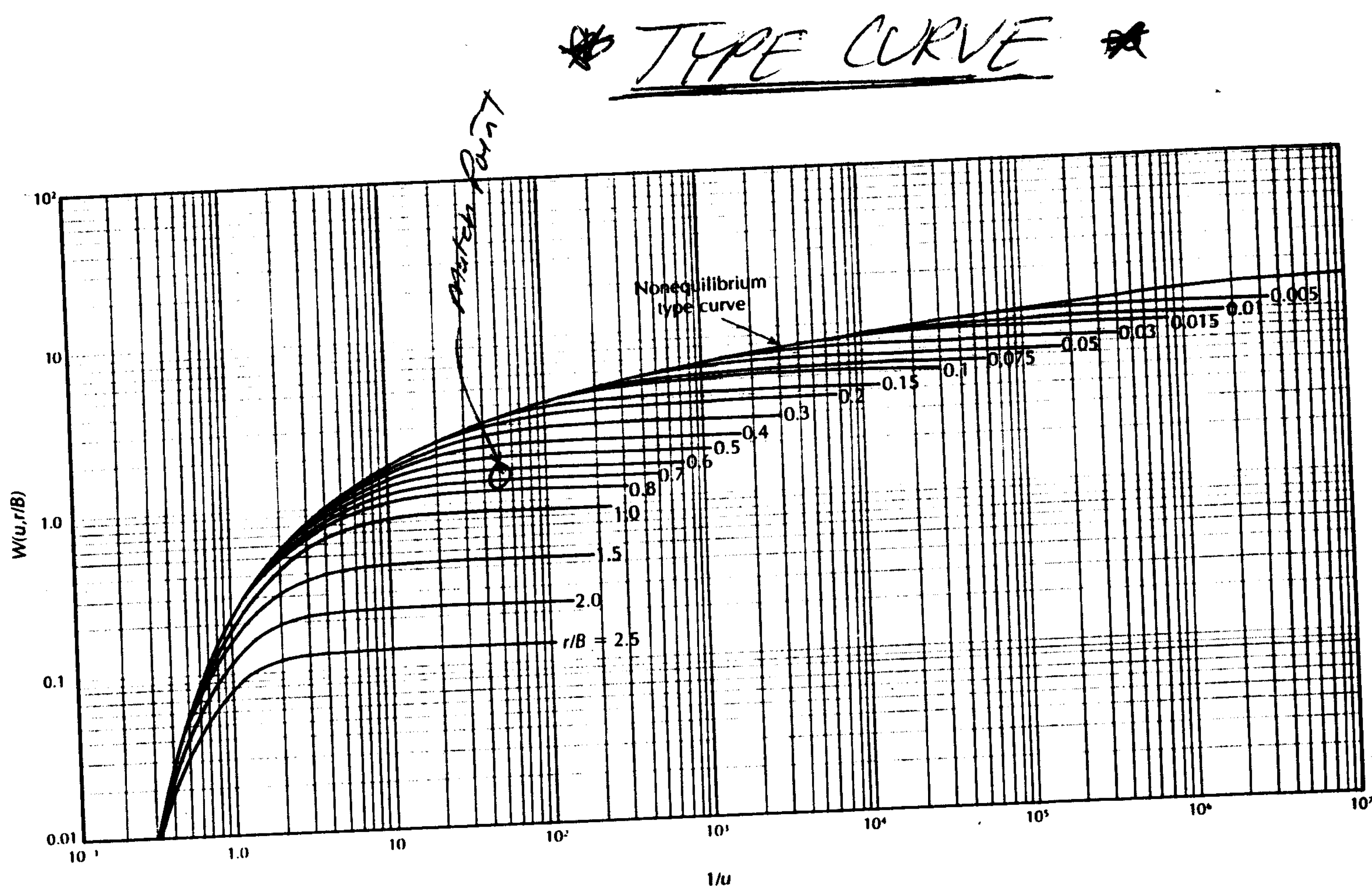



FIGURE 6.13 Type curves of leaky artesian aquifer in which no water is released from storage in the confining layer. Source: W. C. Walton, Illinois State Water Survey Bulletin 49, 1962.



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2) Use Nguyen and Pinder Method

$r_c = 2.54 \cdot 10^{-2} m$ $\qquad z_1 = 0$

$r_s = 2.54 \cdot 10^{-2} m$ $\qquad z_2 = 2.3 m$

Plot: $\ln(H_t)$ vs $\ln(t)$

and

$\ln\left(-\frac{\Delta H_t}{\Delta t}\right)$ vs $\frac{1}{t}$

$C_3 = 0.577$ (see attached spreadsheet)

$C_4 = 32.5$

$$S = \frac{r_c^2}{r_s^2}\frac{C_3}{z_2 - z_1} = \frac{0.557}{2.3} = 0.242$$

$$K = \frac{r_c^2}{4C_4}\frac{C_3}{z_2 - z_1} = \frac{(2.54 \cdot 10^{-2})^2}{4(32.5)} \cdot \frac{0.557}{2.3 m} = 1.201 \cdot 10^{-6} m/sec$$

** May wish to use Hvorslev method to check result for K.

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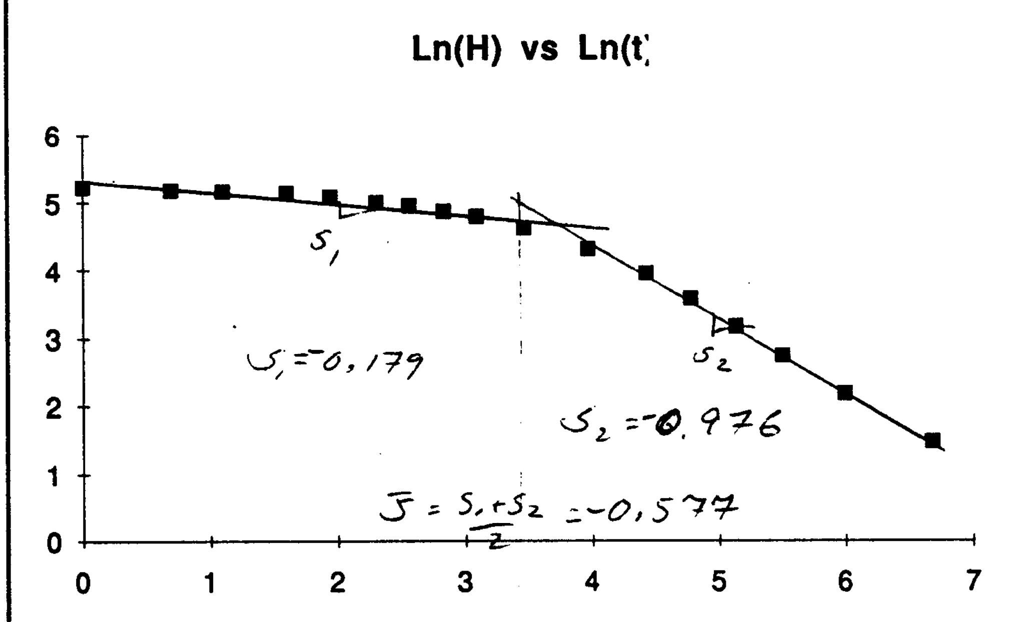
HW5 Problem #2 Slug Test

| 1/t | dh/dt | time | H(time) | ln(t) | ln(H) |
|---|---|---|---|---|---|
| #DIV/0! | | 0 | 197.3 | #NUM! | 5.284725413 |
| 1 | 11.9 | 1 | 185.4 | 0 | 5.222515653 |
| 0.5 | 6.8 | 2 | 178.6 | 0.693147181 | 5.185148668 |
| 0.333333333 | 5 | 3 | 173.6 | 1.098612289 | 5.156753802 |
| 0.2 | 2.95 | 5 | 167.7 | 1.609437912 | 5.122176669 |
| 0.142857143 | 4.45 | 7 | 158.8 | 1.945910149 | 5.067645549 |
| 0.1 | 3.933333333 | 10 | 147 | 2.302585093 | 4.990432587 |
| 0.076923077 | 2.333333333 | 13 | 140 | 2.564949357 | 4.941642423 |
| 0.058823529 | 2.7 | 17 | 129.2 | 2.833213344 | 4.861361591 |
| 0.045454545 | 2.16 | 22 | 118.4 | 3.091042453 | 4.774068722 |
| 0.03125 | 1.88 | 32 | 99.6 | 3.465735903 | 4.601162165 |
| 0.018867925 | 1.219047619 | 53 | 74 | 3.970291914 | 4.304065093 |
| 0.011904762 | 0.732258065 | 84 | 51.3 | 4.430816799 | 3.937690752 |
| 0.008403361 | 0.457142857 | 119 | 35.3 | 4.779123493 | 3.563882964 |
| 0.005882353 | 0.235294118 | 170 | 23.3 | 5.135798437 | 3.148453361 |
| 0.004081633 | 0.108 | 245 | 15.2 | 5.501258211 | 2.721295428 |
| 0.0025 | 0.041935484 | 400 | 8.7 | 5.991464547 | 2.163323026 |
| 0.00125 | 0.011 | 800 | 4.3 | 6.684611728 | 1.458615023 |

5.222
- 4.601
.621
/3.46

3.143




Ln(dH/dt) vs 1/

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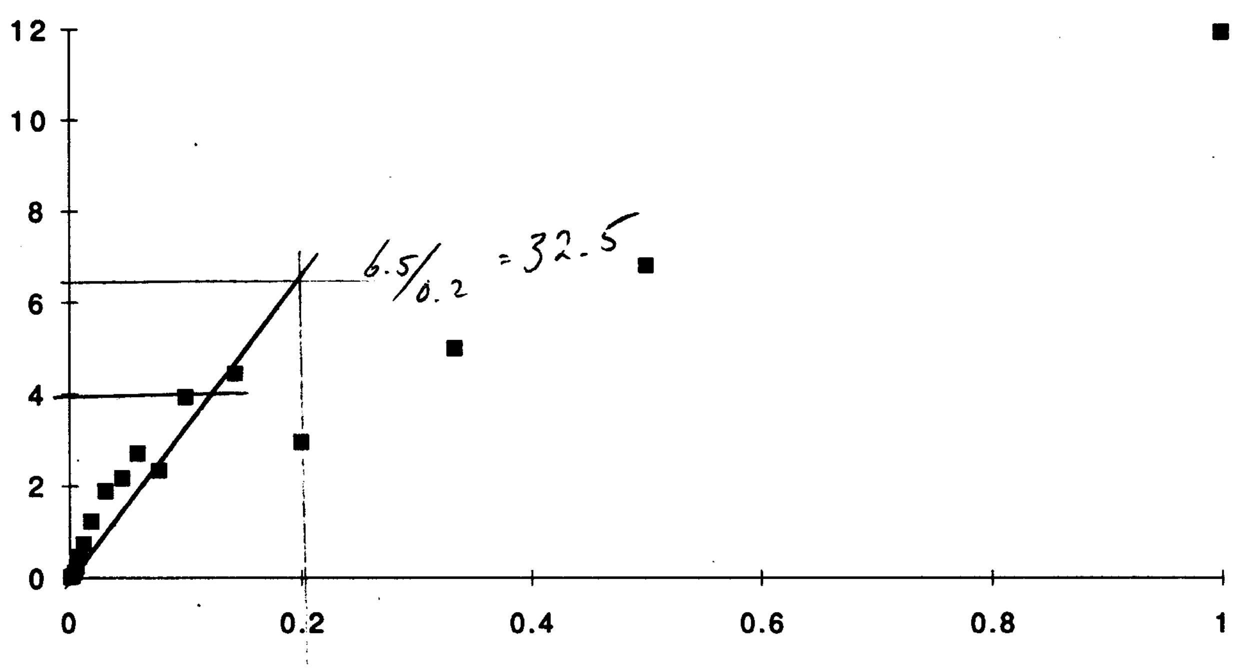
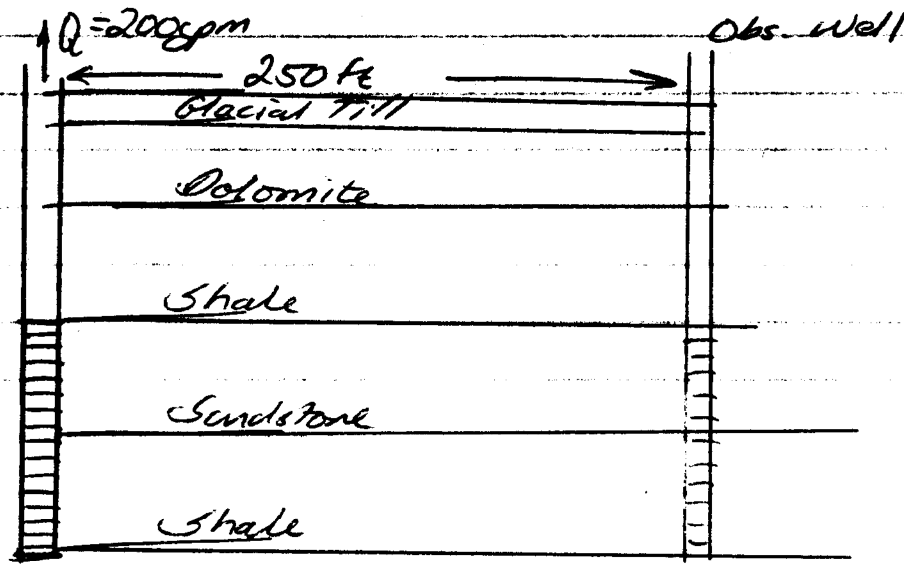
Ln(dH/dt) vs 1/

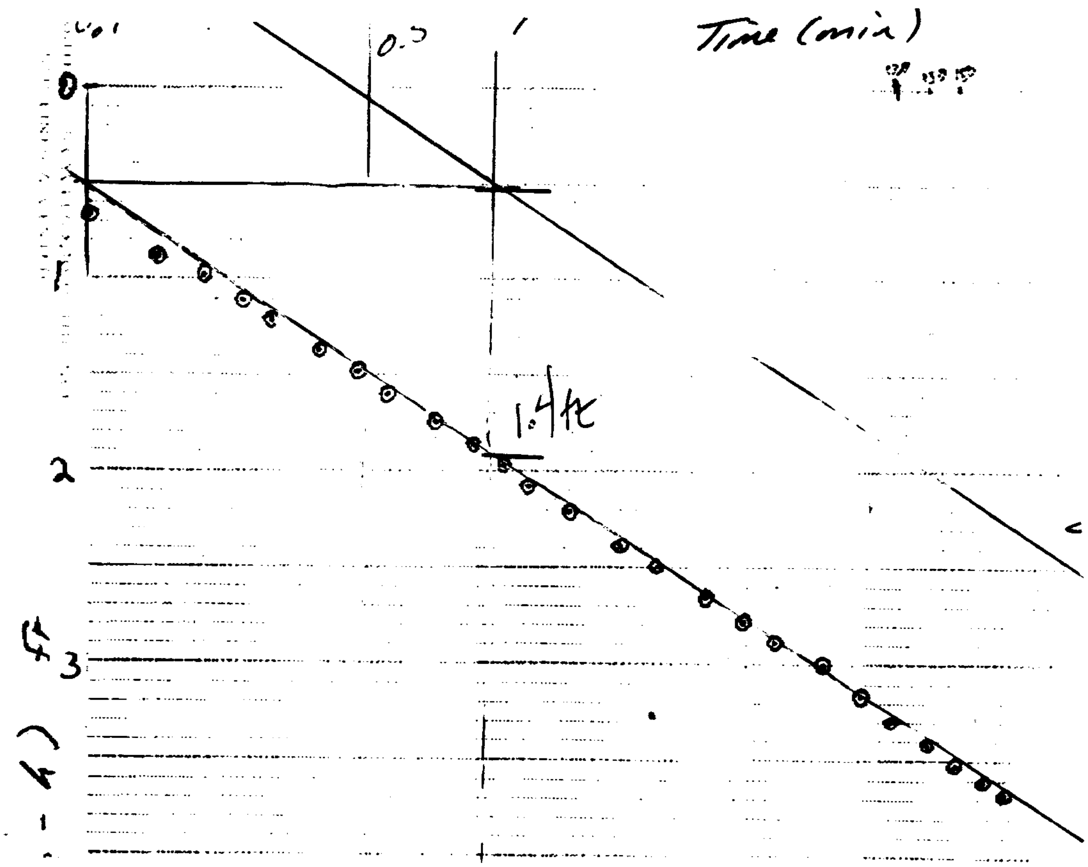


#3 a)




#3 b) attached.

- No evidence of leaky system
- see Jacob-Cooper plot



#3) $r = 250'$, $Q = 200$ gpm

| s (ft) | $t/r^2$ |
|---|---|
| 0.66 | $1.6 \cdot 10^{-5}$ |
| 0.87 | $2.4 \cdot 10^{-5}$ |
| 0.99 | $3.2 \cdot 10^{-5}$ |
| 1.11 | $4.0 \cdot 10^{-5}$ |
| 1.21 | $4.8 \cdot 10^{-5}$ |
| 1.36 | $6.4 \cdot 10^{-5}$ |
| 1.49 | $8.0 \cdot 10^{-6}$ |
| 1.59 | $9.6 \cdot 10^{-5}$ |
| 1.75 | $1.28 \cdot 10^{-4}$ |
| 1.86 | $1.6 \cdot 10^{-4}$ |
| 1.97 | $1.9 \cdot 10^{-4}$ |
| 2.08 | $2.2 \cdot 10^{-4}$ |
| 2.20 | $2.88 \cdot 10^{-4}$ |
| 2.36 | $3.84 \cdot 10^{-4}$ |
| 2.49 | $4.80 \cdot 10^{-4}$ |
| 2.65 | $6.4 \cdot 10^{-4}$ |
| 2.78 | $8.0 \cdot 10^{-4}$ |
| 2.88 | $9.6 \cdot 10^{-4}$ |
| 3.04 | $1.28 \cdot 10^{-3}$ |
| 3.16 | $1.60 \cdot 10^{-3}$ |
| 3.28 | $1.92 \cdot 10^{-3}$ |
| 3.42 | $2.40 \cdot 10^{-3}$ |
| 3.51 | $2.88 \cdot 10^{-3}$ |
| 3.61 | $3.36 \cdot 10^{-3}$ |
| 3.67 | $3.84 \cdot 10^{-3}$ |

Type curves attached

Match Point

$\frac{1}{u} = 27$; $u = 3.704 \cdot 10^{-2}$; $s = 1$ ft

$W(u) = 1.6$ $\quad \frac{t}{r^2} = 10^{-4}$

$T = \frac{200 \text{gpm} (1.6)}{4\pi \, (1 \text{ft})} = 25.46 \text{ gpm/ft}$

$= 4902 \text{ ft}^2/\text{day}$

$S = (3.704 \cdot 10^{-2})(4)(3.404 \frac{\text{ft}^2}{\text{min}})(10^{-4} \frac{\text{min}}{\text{ft}^2})$

$= 4.504 \cdot 10^{-5}$

$T = 4900 \text{ ft}^2/\text{d}$

$S = 4.5 \cdot 10^{-5}$

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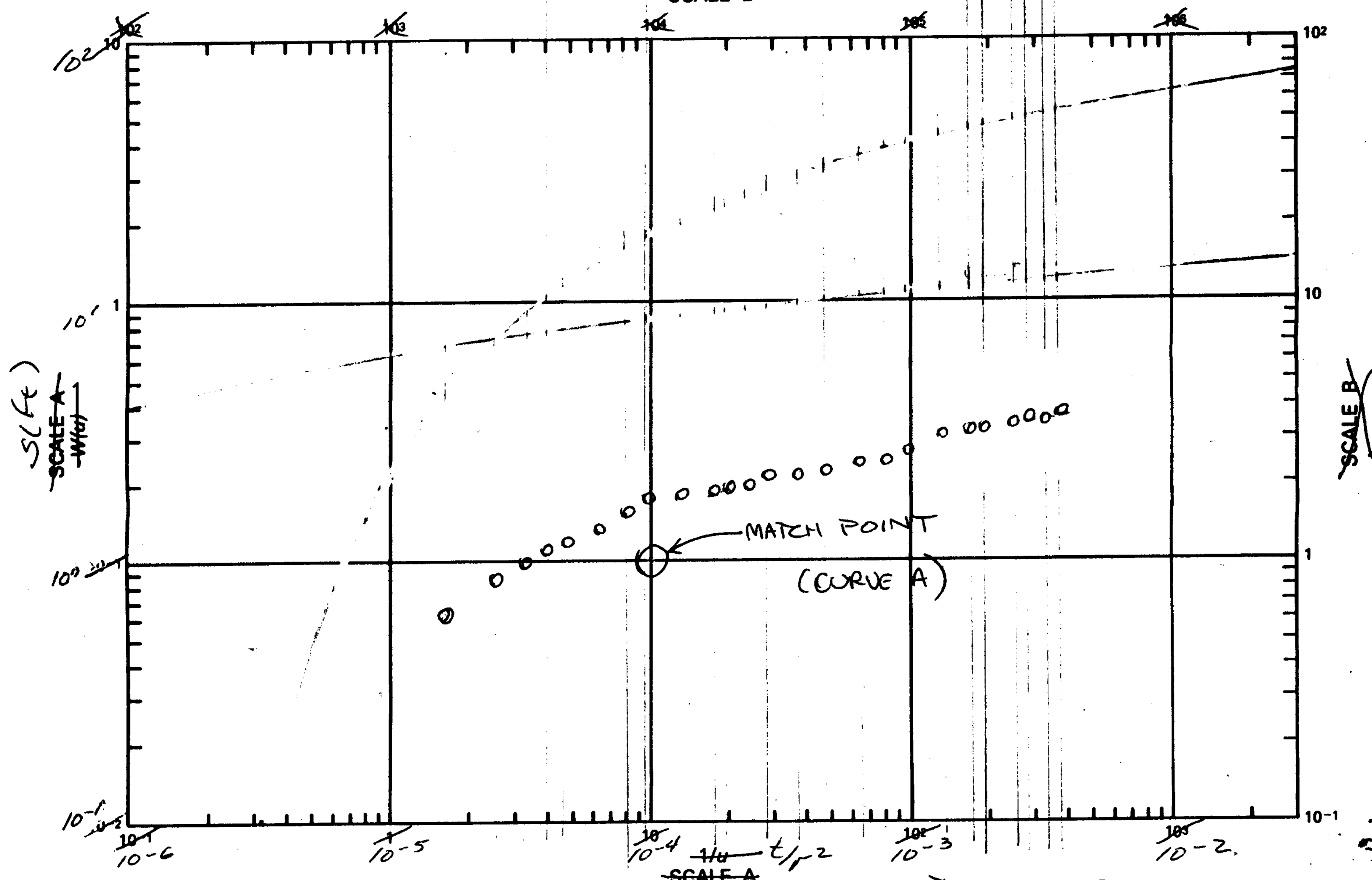


FIGURE 1.2.—Type curve of dimensionless drawdown (W(u)) versus dimensionless time (1/u) for constant discharge from an artesian well (Theis curve)

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GEOLOGICAL SURVEY

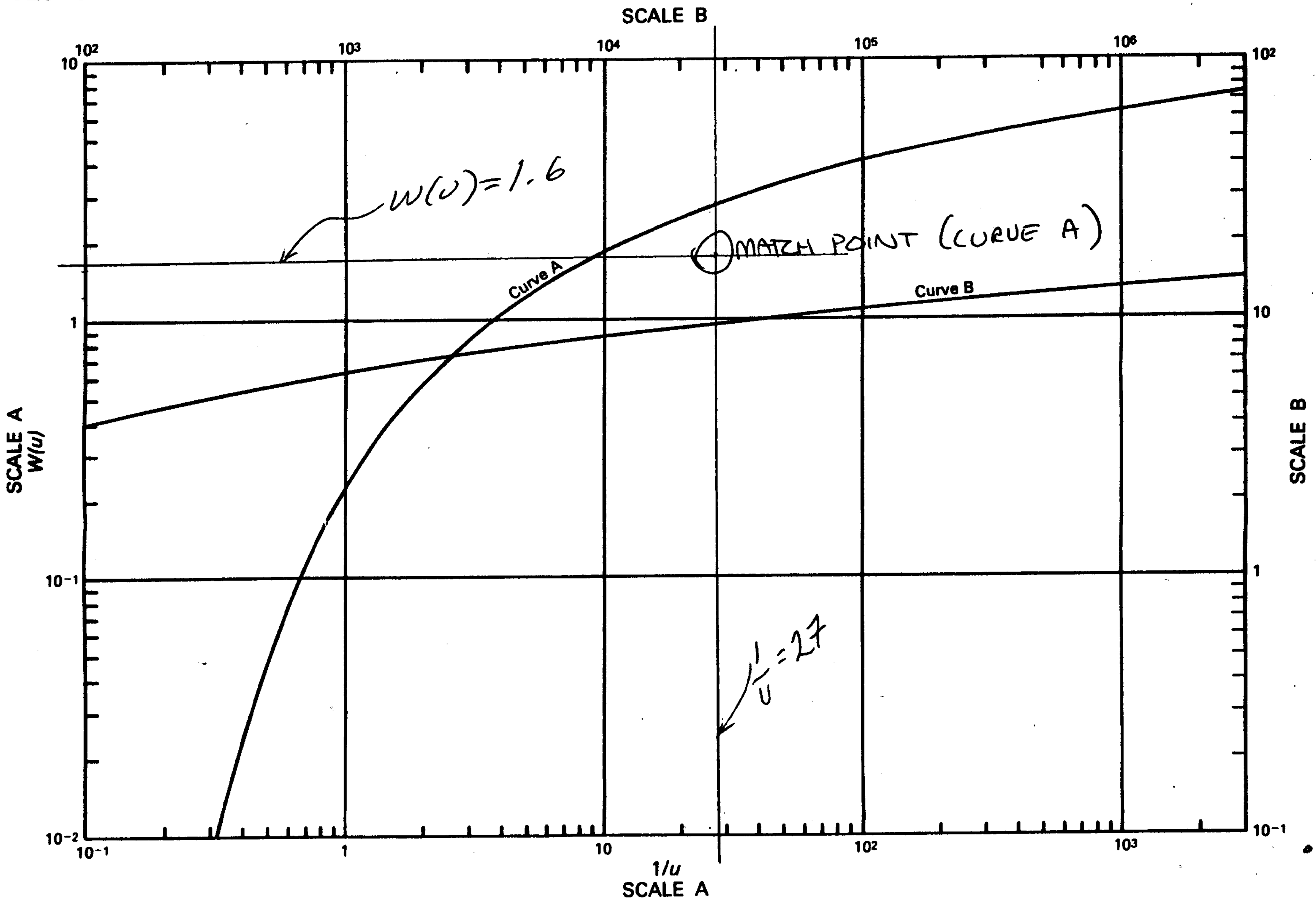
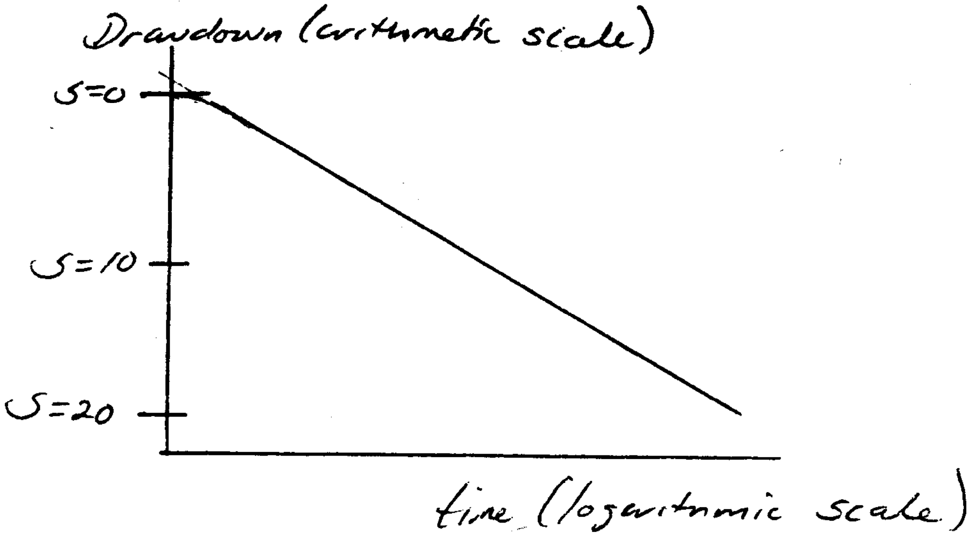


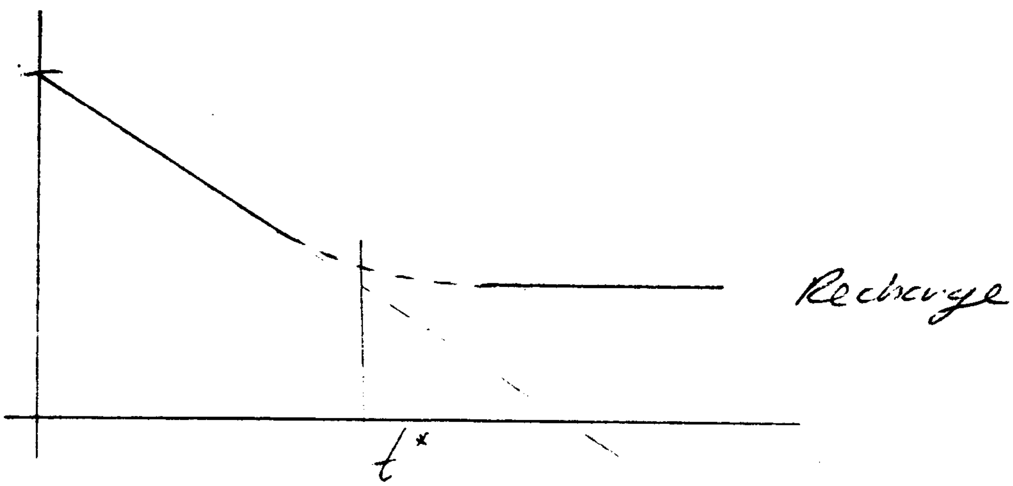

FIGURE 1.2.—Type curve of dimensionless drawdown ($W(u)$) versus dimensionless time ($1/u$) for constant discharge from an artesian well (Theis curve)

H1c1

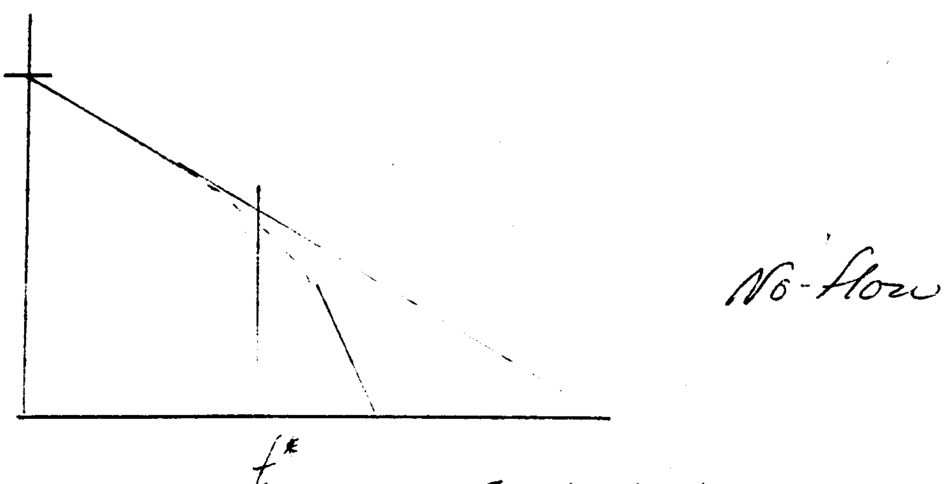
4) a)




b)




c)




$t^*$ should be same for both plots.